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**Stefanakis, Athanasios; Bertram, Finlay; van Gelderen, Laurens; Jomaas, Grunde**

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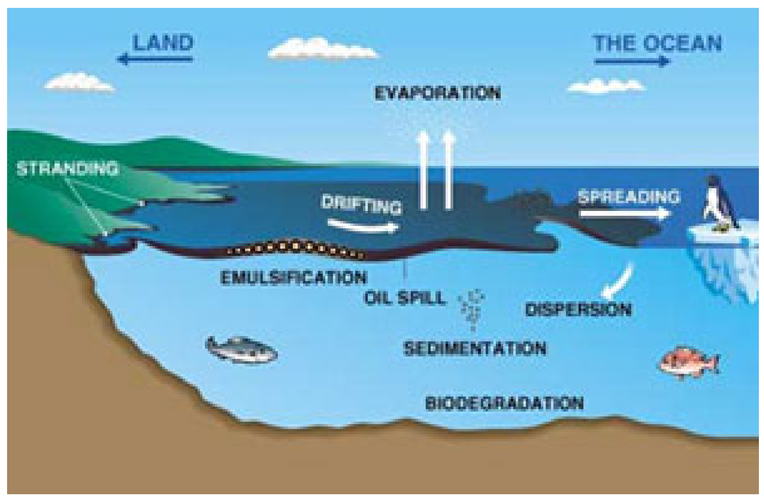
# The effect of emulsification on the *in-situ* burning of crude oil spills

*Athanasios Stefanakis, Finlay Bertram, Laurens van Gelderen, Grunde Jomaas | Civil Engineering, Technical University of Denmark*

## Introduction

Marine oil spills can occur during any phase of the extraction process, storage or delivery. The focus has been to find oil clean up technologies that can be implemented effectively when responding to an oil spill.

Due to environmental conditions an exposed oil pool in oceanic waters is naturally weathered with time. The term weathering encompasses spreading due to the weather conditions, natural dispersion, dissolution and advection (Michel, 2005). In the occurrence of crude oil spills weathering is used to describe the combination of progressive evaporation of the lighter hydrocarbon components of an oil, dispersion and emulsification occurring due to the water oil interaction. Emulsification is the incorporation of water droplets into oil through motion of the supporting water of a marine spill. The emulsification is a time depending process as more water is taken up by the oil slick over time. Depending on the effect of emulsification on the efficiency of in-situ burning, a timely response might be required.




(Ocean policy research foundation)

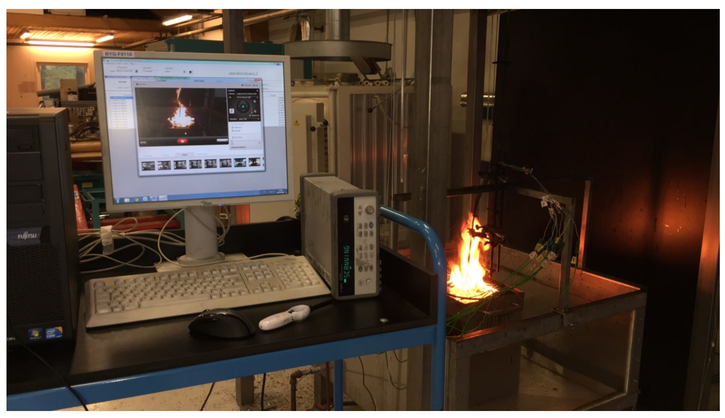
- Ignition based techniques for marine oil spills clean-up, known as “In-Situ Burning,” are in particular of interest under Arctic conditions due to the simplicity and minimal requirement for specialist equipment (Mullin, 2003).
- For combustion to take place 3 elements are required, fuel, oxygen and a source of ignition (Mullin, 2003). The oil spill forms a certain radius of a slick situated above the water as oil is lighter than water. The oil slick on top of the water provides the fuel for process and oxygen is provided by the atmosphere. Ignition of the oil spill occurs as the surface temperature of the slick is heated above a certain temperature were the lighter hydrocarbons are vaporized in sufficient amount in order to sustain combustion. (Opstad & Guénette, 1999)
- The oil slick above the water acts as an insulating barrier between the surface of the water and the volatiles compounds that sustain the burning (Mullin, 2003). The level of the thickness determines the degree of heat loss over to the underlying water. Studies have shown that the minimum required slick for sustainable combustion can vary from 1-3 mm to 10 mm thick. (Mullin, 2003; Opstad & Guénette, 1999).

## Aim

The aim of this research is to study the effect of emulsification on the efficiency of in-situ burning of crude oil. A range of emulsions with an increasing water amount was tested for two crude oils to simulate the time aspect an oil spill response.

## Method

- Outdoor burning experiments were conducted in Sisimiut, Greenland, and were complimented and compared with indoor laboratory experiments.
- Experimental set up comprised of a water tank, Pyrex glass cylinder and extraction hood.



- To simulate the effect of the wave energy acting on an oil slick a rotary emulsifier was used to create the emulsion mixture.
- Oil in water mixture with 20 wt% intervals of water were prepared (i.e. 0, 20, 40, 60 and 80 wt% of water) at a speed of 30 rpm for 18 hours.

- Once the combustion was completed hydrophobic pads were used to collect the burn residue.

(Fritt-Rasmussen, 2010)

Above: Use of Hydrophobic pads

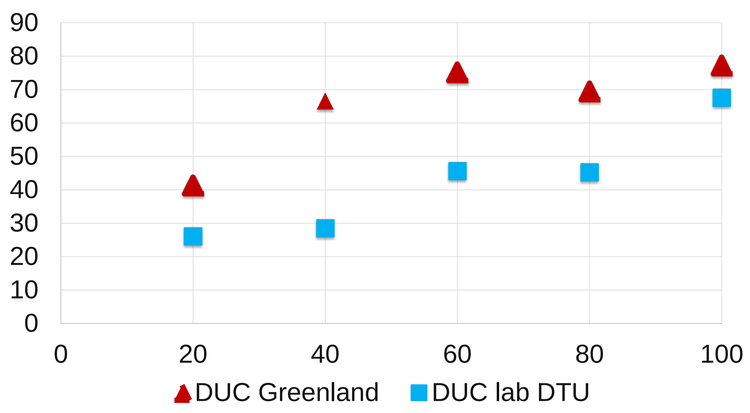
Left: Rotary Emulsifier

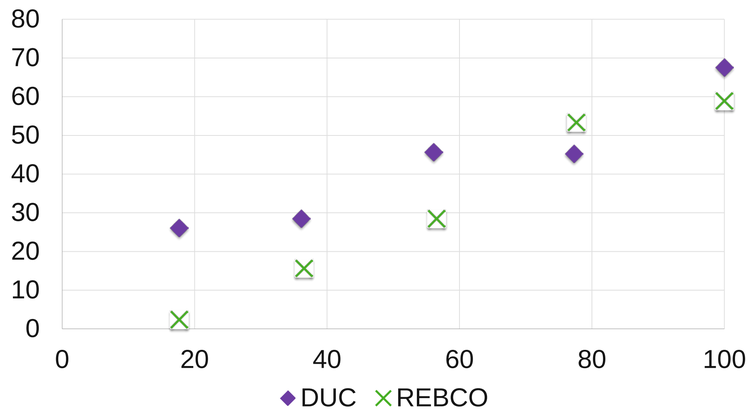
$$Efficiency(\%) = \frac{(Weight\ of\ Emulsion - Weight\ of\ Residual\ Mass)}{Weight\ of\ Emulsion} * 100$$

## Oil Properties

| Sample ID 20 C | Viscosity (mPa*s) v. | Density (g/cm3) | API gravity |
|---|---|---|---|
| **REBCO** | 22 | 0.859 | 31.1 |
| **DUC** | 7.853 | 0.857 | 34.3 |

## Results




- Emulsions became thermodynamically unstable above a water content of 60% for DUC and 20% w/w for REBCO
- The burning efficiency showed an inverse linear correlation with the water content, varying between 68-26% (indoor) and 77-41% (outdoor) for 0 to 80% w/w water content DUC. For REBCO, the efficiencies were 59-2% (indoor) and 70-60 % (outdoor) for 0 to 80% and 0 to 40% water content, respectively.
- Higher burning efficiencies for the outdoor experiments were likely caused by the fact that the burning was wind-aided. Still, this did not affect the observed correlation between the burning efficiency and water content. However, results for the outside experiments might suffer from a higher degree of uncertainty as there were several unmeasured additional parameters in the outdoor environment compared to the laboratory setup.

## Conclusion

Higher burning efficiencies for the outdoor experiments were likely caused by the fact that the burning was wind-aided. Still, this did not affect the observed correlation between the burning efficiency and water content. The results clearly showed that the emulsification of the crude oil has a negative impact on the burning efficiency and thus limits the response time for which *in-situ* burning might be an effective method to clean marine oil spills.

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